Guide Specification Index

PART 1 - GENERAL

1.1 OVERVIEW

This document contains the specification and input/output summaries for a Building Automation System (BAS) for:

<Your customer>

<Insert project name>

<Project location >

The system shall provide the Direct Digital Control (DDC), Energy Management and Building Automation System (BAS) for the air conditioning, heating and ventilating systems and shall interface with other microprocessor based building subsystems as shown on the drawings and as specified.

1.2 INSTRUCTIONS TO BIDDERS

The system specified in this document shall be WebCTRL®, manufactured by Automated Logic Corporation **<Insert any special bidding instructions such as Base Bid, Alternates, etc>.**

Alternate systems are acceptable providing they comply with the native BACnet architecture, web browser access described in this specification and the attached I/O Points Schedule. Alternate systems shall be manufactured by: **<Insert Company A and/or Company B>.**

1.3 SCOPE OF WORK

A. Contractor's Responsibilities

The Contractor shall furnish and install all necessary software and hardware, wiring, pneumatic tubing, and computing equipment in compliance with this specification. Any variances from this specification or related documentation shall be submitted in writing at the time of bid.

B. System Requirements

1. **Standard Material/Products.** All material and equipment used shall be standard components, regularly manufactured and available, and not custom designed especially for this project
2. **Modular Design.** The system architecture shall be fully modular permitting expansion of application software, system peripherals, and field hardware.
3. **Performance.** The system, upon completion of the installation and prior to acceptance of the project, shall perform all operating functions as detailed in this specification.

C. Equipment

1. **System Hardware**

   The Contractor shall provide the following:

   a. PC's, PDA's, server(s), routers, modems and control modules as specified.

   b. All sensing devices, relays, switches, indicating devices, and transducers required to perform the functions as listed in I/O Summary Tables.

   c. All monitoring and control wiring and air tubing.

2. **System Software**

The Controls Contractor shall provide all software identified in Part 2 of this specification, including the BAS Server, fully configured database, graphics, reports, alarm/events. The Graphical User Interface (GUI) shall be completely Web based as specified herein.

D. Input/Output Point Summary Schedule

The system as specified shall monitor, control, and calculate all of the points and perform all the functions as listed in I/O Point Summary Schedule attached as Addendum A to this specification.

E. Codes and Regulations

1. **Standards Authority.** All electrical equipment and material, and its installation, shall conform to the current requirements of the following authorities:
   a. Occupational Safety and Health Act (OSHA)
   b. National Electric Code (NEC)
   c. National Fire Code
   d. Uniform Mechanical Code
   e. Uniform Building Code
   f. Uniform Plumbing Code
2. **Product Applicable Standards.** All distributed, standalone and unitary controllers supplied shall be in compliance with the following listings and standards:
   a. UL916 for Open Energy Management (for U.S. and Canada)
   b. FCC Part 15, Sub-Part B, Class A
   c. CE Electro Magnetic Compatibility
   d. <UUKL Optional: Only for Smoke Evacuation and where specified elsewhere>
3. **Manufacturer's Quality System.** The control system manufacturer shall be ISO9001 listed for design and manufacture of environmental control systems for precise control and comfort, indoor air quality, HVAC plant operation, energy savings and preventative maintenance. ISO Certification shall be by a registrar that is accredited by an internationally recognized organization such as BSI (British Standards Institute). Copy of ISO9001 certificate shall be submitted with bid.
4. **Conflict of Codes.** Where two or more codes conflict, the most restrictive shall apply. Nothing in this specification or related documentation shall be construed to permit work not conforming to applicable codes.

1.4 GENERAL CONDITIONS

A. Changes in Scope of Work

Any changes in the scope of work must be authorized by a written Change Order, and issued by **<your customer>,** in accordance with Contract conditions.

B. Correction of Work

1. **Contractor's Responsibility.** The Contractor shall promptly correct all work **<Your customer>** finds defective or failing to conform to the Contract Documents. The Contractor shall bear all cost of correcting such work.

2. **During Warranty.** If, within the warranty period required by the Contract Documents, any of the work is found to be defective or not in accordance with the Contract Documents, the Contractor shall correct it promptly after receipt of a written notice from **<Your customer>** to do so. **<Your customer>** shall give notice promptly after discovery of the condition.

C. Coordination of Work During Construction

1. The Contractor shall coordinate any necessary changes in work scheduling with **<Your customer>** to minimize disruption.
    a. The Contractor shall protect the installed works by other trades.
    b. The Contractor shall coordinate with other trades.
    c. The Contractor shall repair any damage caused by his work to building(s) and equipment at no additional cost to the owner.

D. Warranty

The Contractor shall warrant, from the date of final acceptance by **<Your customer>,** that all systems, subsystems, component parts, and software are fully free from defective design, materials, and workmanship for a period of one year or longer as indicated in this specification.

1.5 SUBMITTALS, DOCUMENTATION, ACCEPTANCE AND TRAINING

A. Submittals

1. **Shop Drawings.** A minimum of **<Insert minimum number of x copies>** copies of shop drawings shall be submitted and shall consist of a complete list of equipment, materials, manufacturer's technical literature, cut-sheets, and installation instructions. Drawings shall contain proposed layout, complete wiring, routing, schematic diagrams, tag number of devices, software descriptions, calculations, installation details, and any other details required to demonstrate that the system will function properly.
2. **Drawing Approval.** Shop drawings shall be approved before any equipment is installed. Controls contractor shall allow a minimum of **<x days>** for drawing approval.
3. **As Built Drawings.** All drawings shall be reviewed after the final system checkout and updated or corrected to provide 'as-built' drawings to show exact installation. All shop drawings will be acknowledged in writing by **<Your customer>** before installation is started and again after the final checkout of the system. The system will not be considered complete until the 'as-built' drawings have received their final approval. The Contractor shall deliver **<x>** sets of 'as-built' drawings.

B. Documentation

Operating and Maintenance (O&M) manuals for the system shall be made available electronically and include the following categories: Workstation User's Manual, Project Engineering Handbook, and Software Documentation.

1. **BAS User's Manual** shall contain as a minimum:
    a. System overview
    b. Networking concepts
    c. Launching a web browser from a networked PC and login
    d. Web Browser Graphical User Interface (GUI) screen menus and their definitions

e. Creating, modifying or deleting schedules

f. Uploading and downloading software to the field hardware

g. Creating historical trends, collecting trend data and generating trend graphs

h. Enabling and assigning alarms and messages to reporting actions/groups

i. Report generation and 'third party software'

j. Backing up software and data files

2. **Project Engineering Manual** for <**customers project** > shall contain as a minimum:

   a. System architecture overview and networking configuration

   b. Hardware cut-sheets and product descriptions

   c. The Contractor shall deliver **<x>** sets of 'as-built' drawings. All drawings shall be reviewed after the final system checkout and updated to provide 'as-built' drawings. The system will not be considered complete until the 'as-built' drawings have received their final approval.

   d. Installation, mounting and connection details for all field hardware and accessories

   e. Commissioning, setup and backup procedures for all control modules/accessories, BAS server software, and database.

   f. Listing of basic terminology, alarms/messages, error messages and frequently used commands or shortcuts.

3. **BAS Software Documentation** shall contain as a minimum:

   a. The Contractor shall provide all Graphical Programs, detailing their application to specific HVAC equipment and electrical/mechanical subsystems, together with a glossary or icon symbol library detailing the function of each graphical icon. Revisions made as a result of the submittal process, during the installation, start-up or acceptance portion of the project, shall be accurately reflected in the "as-builts".

   b. Graphical representation of the mechanical equipment hierarchy for the project including all equipment controlled by the BAS. For example: a VAV terminal box may be the source for increased cooling demand and require the primary VAV AHU to operate which, in turn, requires the chillers to operate.

   c. Detailed listing of all alarm and event messages programmed for designated mechanical/electrical equipment and required operator action.

C. Acceptance Test

1. **Acceptance Testing.** Upon completion of the installation, the Contractor shall start up the system and perform all necessary calibration, testing, and debugging operations. The Contractor in the presence of the Owner's representative shall perform an acceptance test.

2. **Notice of Completion.** When the system performance is deemed satisfactory, the system parts will be accepted for beneficial use and placed under warranty. At this time, **<Your customer>** shall issue a "notice of completion" and the warranty period shall start.

D. System Training

1. **System Use Instructions:** Controls Contractor shall provide full Computer Based Training (CBT) in addition to training of designated personnel in the operation, maintenance, and programming of the system.

PART 2 – BAS SERVER & WEB BROWSER GUI

2.1 SYSTEM OVERVIEW

The BAS contractor shall provide system software based on a server/thin-client architecture, designed around the open standards of web technology. The BAS server shall communicate using ASHRAE's BACnet/IP protocol, and in addition, offer concurrent support over the same data-link of the following protocols: LonWorks, MODBUS, and SNMP. Server shall be accessed using a web browser over **<your customer>** intranet and remotely over the Internet.

The intent of the thin-client architecture is to provide the operator(s) complete access to the BAS system via a web browser. The thin-client web browser Graphical User Interface (GUI) shall be browser and operating system agnostic, meaning it will support Microsoft and Netscape Navigator browsers (5.5 or later versions), and Windows as well as non-Window operating systems. No special software, (active-x components or fat java clients) shall be required to be installed on the PC's / PDA's used to access the BAS via a web browser.

The BAS server software must support at least the following server platforms (Windows NT, Sun Solaris and Linux). The BAS server software shall be developed and tested by the manufacturer of the system standalone controllers and network controllers/routers. Third party manufactured and developed BAS software is not acceptable.

The web browser GUI shall provide a completely interactive user interface and must offer the following features as a minimum:

- Trending
- Scheduling
- Downloading Memory to field devices
- Real time 'live' Graphic Programs
- Tree Navigation
- Parameter change of properties
- Setpoint Adjustments
- Alarm / Event information
- Configuration of operators
- Execution of global commands

A. Software Components

All software components of the BAS system software shall be installed and completed in accordance with the specification. BAS system components shall include:

1. Server Software, Database and Web Browser Graphical User Interface
2. System Configuration Utilities for future modifications to the system
3. Graphical Programming Tools
4. Direct Digital Control software
5. Application Software

B. BAS Server Database

The BAS server software shall utilize a Java DataBase Connectivity (JDBC) compatible database such as: MS Access, MS SQL 8.0, Oracle 8i or IBM DB2. BAS systems written to Non standard and/or Proprietary databases are **NOT** acceptable.

C. Database Open Connectivity

The BAS server database shall be Java DataBase Connectivity (JDBC) compatible, allowing real time access of data via the following standard mechanisms:

1. Open protocol standard like CORBA or SOAP
2. OLE/OPC (for Microsoft Client's/Server platform only)
3. Import/Export of the database from or to XML (eXtensible Mark-up Language)

D. Communication Protocol(s)

The native protocol for the BAS server software shall be BACnet over Ethernet DataLink as defined by ASHRAE standard SPC135. The BAS Server shall support BACnet/IP Annex J to enable communication through common routers. Proprietary protocols over TCP/IP are NOT acceptable. In addition, the software shall be able to support concurrent operation of multiple standard and non-standard protocols such as:

1. ***Automated Logic's Legacy Protocol***
2. SMNP
3. LonWorks over IP*

* **IMPORTANT NOTE:** LonMark or LonWorks devices must be networked from LonTalk to an Ethernet Datalink and IP data structure, using a LonTalk to IP Router like an ***i1000 Echelon Router***. Binding of all LON devices including Domain, Subnet, Node ID, and the SNVT's structure, in addition to configuration of all network variables for IP tunneling shall be the responsibility of the LON device supplier. ALL I/O points listed in the I/O Point Summary shall be configured through the i1000 LON/IP router(s). A copy of Echelon's proprietary LNS Services and LON Manager shall be supplied at no cost to **<your customer>** by the supplier of the LON devices.

E. Cross Platform Capability

The BAS system software (client and server) shall be operating system and hardware agnostic, being able to run on Windows 2000, Windows NT, Windows XP, Sun Microsystems Solaris and Red Hat Linux

F. Thin Client – Web Browser Based

The GUI shall be thin client or browser based and shall meet the following criteria:

1. **Web Browser's for PC's:** Only a 5.5 or later browser (Explorer/Navigator) will be required as the GUI, and a valid connection to the server network. No installation of any custom software shall be required on the operator's GUI workstation/client. Connection shall be over an intranet or the Internet. A firewall shall be installed (as necessary) to protect <your customers> Intranet.
2. **Secure Socket Layers:** Communication between the Web Browser GUI and BAS server shall offer encryption using 128-bit encryption technology within Secure Socket Layers (SSL). Communication protocol shall be Hyper-Text Transfer Protocol (HTTP).
3. **PDA's:** BAS Server software must support other browsers used by Personal Digital Assistants like 3Com Palm Pilots and other Internet appliances specified herein.

2.2 WEB BROWSER GRAPHICAL USER INTERFACE

A. Web Browser Navigation

The Thin Client web browser GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to "feel" like a single application, and provide a complete and intuitive mouse/menu driven operator interface. It shall be possible to navigate through the system using a web browser to accomplish 2.2 B thru 2.2 J of this specification. The Web Browser GUI shall (as a minimum) provide a Navigation Pane for navigation, and a Action Pane for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic setpoint controls, configuration menus for operator access, reports, and reporting actions for events.

B. Login

On launching the web browser and selecting the appropriate domain name or IP address, the operator shall be presented with a login page that will require a login name and password. Navigation in the system shall be dependent on the operator's role privileges, and geographic area of responsibility (see 3.2 J below).

C. Navigation Pane

The Navigation Pane shall comprise a Navigation Tree which defines a geographic hierarchy of **<your customers>** BAS system. Navigation through the GUI shall be accomplished by clicking on appropriate level of a navigation tree (consisting of expandable and collapsible tree control like Microsoft's Explorer program), and/or by selecting dynamic links to other system graphics. Both the navigation tree and action pane defined in 2.2 D shall be displayed simultaneously, enabling the operator to select a specific system or equipment, and view the corresponding graphic. The navigation tree shall as a minimum provide the following views: Geographic, Network, Groups and Configuration.

1. **Geographic View** shall display a logical geographic hierarchy of the system including: cities, sites, buildings, building systems, floors, equipment and BACnet objects.
2. **Network View** shall display the hierarchy of the actual BACnet IP Intranet network. This can include: Systems, Site, Networks, Routers, Half-Routers, Devices, Equipment and all the BACnet Objects in a device.
3. **Groups View** shall display Scheduled Groups and custom reports.
4. **Configuration View** shall display all the configuration categories (Operators, Schedule, Event, Reporting and Roles).

   The navigation tree shall have a view selector to enable/disable various types of tree ornaments, like a clock to indicate where schedules have been assigned in the building

D. Action Pane

The Action Pane shall provide several functional views for each HVAC or mechanical/electrical subsystem specified. A functional view shall be accessed by clicking on the corresponding button:

1. **Graphics:** Using animated gifs or other graphical format suitable for display in a web browser, graphics shall include aerial building/campus views, color building floor-plans, equipment drawings, active graphic setpoint controls, web content, and other valid HTML elements. The data on each graphic page shall automatically refresh at a rate defined by the operator.
2. **Properties:** Shall include graphic controls and text for the following: Locking or overriding BACnet objects, demand strategies, and any other valid data required for setup. Changes made to the properties pages shall require the operator to depress a 'accept/cancel' button.

3. **Schedules**: Shall be used to create, modify/edit and view schedules based on the systems geographical hierarchy (using the navigation tree) and in compliance with section 2.2.G
4. **Events:** Shall be used to view alarm event information geographically (using the navigation tree), acknowledge events, sort events by category, actions and verify reporting actions.
5. **Trends:** Shall be used to display associated trend and historical data, modify colors, date range, axis and scaling
6. **Logic - Live Graphic Programs:** Shall be used to display a 'live' graphic programs of the control algorithm for the mechanical/electrical system selected in the navigation tree.

Other actions such as Print, Help, Command, and Logout shall be available via a drop-down window.

E. Color Graphics

The Web Browser GUI shall make extensive use of color in the graphic pane to communicate information related to setpoints and comfort. Animated .gif's or .jpg, active setpoint graphic controls shall be used to enhance usability. Graphics tools used to create Web Browser graphics shall be non-proprietary and conform to the following basic criteria:

1. **Display Size:** The GUI workstation software shall graphically display in 1024 by 768 pixels 24 bit True Color.
2. **General Graphic:** General area maps shall show locations of controlled buildings in relation to local landmarks.
3. **Color Floor Plans:** Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, which provide a visual display of temperature relative to their respective setpoints (see section 3.2 F below). The colors shall be updated dynamically as a zone's actual comfort condition changes.
4. **Mechanical Components:** Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability.
5. **Minimum System Color Graphics:** Color graphics shall be selected and displayed via a web browser for the following:
    a. Each piece of equipment monitored or controlled including each terminal unit
    b. Each building
    c. Each floor and zone controlled

F. Zone Setpoint Adjustments

Color floor plans displayed via a web browser shall utilize a contiguous band of colors, each corresponding to actual zone temperatures relative to the desired heating and cooling setpoints. The ideal temperature shall be shown as a green color band. Temperatures slightly warmer than ideal shall be shown in yellow, and even warmer temperature band shall be shown in orange. Temperatures slightly cooler than ideal shall be light blue, and even cooler temperatures shall be shown as dark blue. All alarm colors shall be in red.

1. **Active Zone Graphic Setpoint Controls:** Utilizing a mouse, it shall be possible to select occupied or unoccupied setpoints (corresponding to the floor plan colors) and drag the color slide bar(s) to increase or decrease heating and cooling setpoints. In addition to the slide bars, an operator may type the numeric value of the heating and cooling setpoints. The floor plan

graphic shall then change colors on a zone-by-zone basis to reflect the actual temperature in each zone relative to the changed heating or cooling setpoint.

G. Hierarchical Schedules

Utilizing the Navigation Tree displayed in the web browser GUI, an operator (with password access) shall be able to define a Normal, Holiday or Override schedule for an individual piece of equipment or room, or choose to apply a hierarchical schedule to the entire system, site or floor area. For example, Independence Day 'Holiday' for every level in the system would be created by clicking at the top of the geographic hierarchy defined in the Navigation Tree. No further operator intervention would be required and every control module in the system with would be automatically downloaded with the 'Independence Day' Holiday.

All schedules that affect the system/area/equipment highlighted in the Navigation Tree shall be shown in a summary schedule table and graph.

1. **BACnet Schedules:** Schedules shall comply with the BACnet standard, (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and shall allow events to be scheduled based on:
    a. Types of schedule shall be Normal, Holiday or Override
    b. A specific date,
    c. A range of dates,
    d. Any combination of Month of Year (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any)
    e. Wildcard (example, allow combinations like second Tuesday of every month).
2. **Schedule Categories:** The system shall allow operators to define and edit scheduling categories (different types of "things" to be scheduled; for example, lighting, HVAC occupancy, etc.). The categories shall include: name, description, icon (to display in the hierarchy tree when icon option is selected) and type of value to be scheduled.
3. **Schedule Groups:** In addition to hierarchical scheduling, operators shall be able to define functional Schedule Groups, comprised of an arbitrary group of areas/rooms/equipment scattered throughout the facility and site. For example, the operator shall be able to define an 'individual tenant' group – who may occupy different areas within a building or buildings. Schedules applied to the 'tenant group' shall automatically be downloaded to control modules affecting spaces occupied by the 'tenant group'
4. **Intelligent Scheduling:** The control system shall be intelligent enough to automatically turn on any supporting equipment needed to control the environment in an occupied space. If the operator schedules an individual room in a VAV system for occupancy, for example, the control logic shall automatically turn on the VAV air handling unit, chiller, boiler, and/or any other equipment required to maintain the specified comfort and environmental conditions within the room.
5. **Partial Day Exceptions:** Schedule events shall be able to accommodate a time range specified by the operator (ex: board meeting from 6 pm to 9 pm overrides Normal schedule for conference room).
6. **Schedule Summary Graph:** The schedule summary graph shall clearly show Normal versus Holiday versus Override Schedules, and the net operating schedule that results from all contributing schedules. Note: In case of priority conflict between schedules at the different geographic hierarchy, the schedule for the more detailed geographic level shall apply.
7. **Schedule Distribution:** For reliability and performance, instead of maintaining a single schedule in a field device that writes over the network to notify other devices when a

scheduled event occurs, field devices will only keep their part of the schedule locally. The BAS server software shall determine which nodes a hierarchical schedule applies to and will create/modify the necessary schedule objects in each field device as necessary.

H. Events (& Alarms)

Events and alarms associated with a specific system, area, or equipment selected in the Navigation Tree, shall be displayed in the Action Pane by selecting an 'Events' view. Events, alarms, and reporting actions shall have the following capabilities:

1. **Events View:** Each event shall display an Event Category (using a different icon for each event category), date/time of occurrence, current status, event report, and a **bold** URL link to the associated graphic for the selected system, area or equipment. The URL link shall indicate the system location, address and other pertinent information. An operator shall easily be able to sort events, edit event templates and categories, acknowledge or force a return to normal in the Events View as specified in this section.
2. **Event Categories:** The operator shall be able to create, edit or delete event categories such as HVAC, Maintenance, Fire, or Generator. An icon shall be associated with each Event category, enabling the operator to easily sort through multiple events displayed.
3. **BACnet Event Templates:** BACnet Event template shall define different types of alarms and their associated properties. As a minimum, properties shall include a reference name, verbose description, severity of event, acknowledgement requirements, high/low limit and out of range information.
4. **Event Areas:** Event Areas enable a operator to assign specific Event Categories to specific Event Reporting Actions. For example, it shall be possible for an operator to assign all HVAC Maintenance events on the 1st floor of a building to email the technician responsible for maintenance. The Navigation Tree shall be used to setup Event Areas in the Graphic Pane.
5. **Event Time/Date Stamp:** All events shall be generated at the DDC control module level and comprise the Time/Date Stamp using the standalone control module time and date.
6. **Event Configuration:** Operators shall be able to define the type of events generated per BACnet object. A 'network' view of the Navigation Tree shall expose all BACnet objects and their respective Event Configuration. Configuration shall include assignment of event, alarm, type of Acknowledgement and notification for return to normal or fault status.
7. **Event Summary Counter:** The view of events in the Graphic Pane shall provide a numeric counter, indicating how many events are active (in alarm), require acknowledgement, and total number of events in the BAS Server database.
8. **Event Auto-Deletion:** Events that are acknowledged and closed, shall be auto-deleted from the database and archived to a text file after an operator defined period.
9. **Event Reporting Actions:** Event Reporting Actions specified shall be automatically launched (under certain conditions) after an event is received by the BAS server software. Operators shall be able to easily define these Reporting Actions using the Navigation Tree and Graphic Pane through the web browser GUI. Reporting Actions shall be as follows:
    a. **Print:** Alarm/Event information shall be printed to the BAS server's PC or a networked printer.
    b. **Email:** Email shall be sent via any POP3-compatible e-mail server (most Internet Service Providers use POP3). Email messages may be copied to several email accounts.

       Note: Email reporting action shall also be used to support alphanumeric paging services, where email servers support pagers.

c. **File Write:** The ASCII File write reporting action shall enable the operator to append operator defined alarm information to any alarm through a text file. The alarm information that is written to the file shall be completely definable by the operator. The operator may enter text or attach other data point information (such as AHU discharge temperature and fan condition upon a high room temperature alarm).

d. **Write Property:** The write property reporting action updates a property value in a hardware module.

e. **SNMP:** The Simple Network Management Protocol (SNMP) reporting action sends an SNMP trap to a network in response to receiving an event.

f. **Run External Program:** The Run External Program reporting action launches specified program in response to an event.

10. **Event Simulator:** The web browser GUI user shall provide an Event Simulator to test assigned Reporting Actions. The operator shall have the option of using current time or scheduling a specific time to generate the Event. Utilizing the Navigation Tree and drop-down menus in the Graphic Pane, the operator shall be able to select the Event Type, Status, Notification, Priority, Message, and whether acknowledgement is required.

I. Trends

Trends shall conform to the BACnet Trend Log Object specification. Trends shall both be displayed and user configurable through the Web Browser GUI. Trends shall comprise analog, digital or calculated points simultaneously. A trend log's properties shall be editable using the Navigation Tree and Graphic Pane.

1. **Viewing Trends:** The operator shall have the ability to view trends by using the Navigation Tree and selecting a Trends button in the Graphic Pane. The system shall allow y- and x-axis maximum ranges to be specified and shall be able to simultaneously graphically display multiple trends per graph.

2. **Local Trends:** Trend data shall be collected locally by Multi-Equipment/Single Equipment general-purpose controllers, and periodically uploaded to the BAS server if historical trending is enabled for the BACnet object. Trend data, including run time hours and start time date shall be retained in non-volatile module memory. Systems that rely on a gateway/router to run trends are NOT acceptable.

3. **Resolution.** Sample intervals shall be as small as one second. Each trended point will have the ability to be trended at a different trend interval. When multiple points are selected for display that have different trend intervals, the system will automatically scale the axis.

4. **Dynamic Update.** Trends shall be able to dynamically update at operator-defined intervals.

5. **Zoom/Pan.** It shall be possible to zoom-in on a particular section of a trend for more detailed examination and 'pan through' historical data by simply scrolling the mouse.

6. **Numeric Value Display.** It shall be possible to pick any sample on a trend and have the numerical value displayed.

7. **Copy/Paste.** The operator must have the ability to pan through a historical trend and copy the data viewed to the clipboard using standard keystrokes (i.e. CTRL+C, CTRL+V).

J. Security Access

Systems that Security access from the web browser GUI to BAS server shall require a Login Name and Password. Access to different areas of the BAS system shall be defined in terms of Roles, Privileges and geographic area of responsibility as specified:

1. **Roles:** Roles shall reflect the actual roles of different types of operators. Each role shall comprise a set of 'easily understood English language' privileges.. Roles shall be defined in terms of View, Edit and Function Privileges.

   a. View Privileges shall comprise: Navigation, Network, and Configuration Trees, Operators, Roles and Privileges, Alarm/Event Template and Reporting Action.

   b. Edit Privileges shall comprise: Setpoint, Tuning and Logic, Manual Override, and Point Assignment Parameters.

   c. Function Privileges shall comprise: Alarm/Event Acknowledgement, Control Module Memory Download, Upload, Schedules, Schedule Groups, Manual Commands, Print, and Alarm/Event Maintenance.

2. **Geographic Assignment of Roles:** Roles shall be geographically assigned using a similar expandable/collapsible navigation tree. For example, it shall be possible to assign two HVAC Technicians with similar competencies (and the same operator defined HVAC Role) to different areas of the system.

2.3 GRAPHICAL PROGRAMMING

The system software shall include a Graphic Programming Language (GPL) for all DDC control algorithms resident in standalone control modules. Any system that does not use a drag and drop method of graphical icon programming as described herein is NOT acceptable. GPL is a method used to create a sequence of operations by assembling graphic microblocks that represent each of the commands or functions necessary to complete a control sequence. Microblocks represent common logical control devices used in conventional control systems, such as relays, switches, high signal selectors, etc., in addition to the more complex DDC and energy management strategies such as PID loops and optimum start. Each microblock shall be interactive and contain the programming necessary to execute the function of the device it represents.

Graphic programming shall be performed while on screen and using a mouse; each microblock shall be selected from a microblock library and assembled with other microblocks necessary to complete the specified sequence. Microblocks are then interconnected on screen using graphic "wires," each forming a logical connection. Once assembled, each logical grouping of microblocks and their interconnecting wires then forms a graphic function block which may be used to control any piece of equipment with a similar point configuration and sequence of operation.

A. Graphic Sequence

The clarity of the graphic sequence must be such that the operator has the ability to verify that system programming meets the specifications, without having to learn or interpret a manufacturer's unique programming language. The graphic programming must be self-documenting and provide the operator with an understandable and exact representation of each sequence of operation.

B. Simulation

Full simulation capability shall be provided with the graphic programming. Operator shall be able to fully simulate the constructed control sequence prior to downloading into field control modules. Simulation capabilities shall include step-by-step, accelerated time, and operator defined simulation criteria like outside weather, demand, and communication status. Multiple graphic programs shall be simulated and displayed in split screens at the same time.

C. GPL Capabilities

The following is a minimum definition of the capabilities of the Graphic Programming software:

1. **Function Block (FB):** Shall be a collection of points, microblocks and wires which have been connected together for the specific purpose of controlling a piece of HVAC equipment or a single mechanical system.
2. **Logical I/O:** Input/Output points shall interface with the control modules in order to read various signals and/or values or to transmit signal or values to controlled devices.
3. **BACnet Points:** Shall be points that comply with the BACnet structure as defined in the BIBB's Addendum B1/B2, and the BACnet standard.
4. **Microblocks:** Shall be software devices that are represented graphically and may be connected together to perform a specified sequence. A library of microblocks shall be submitted with the control contractors bid.
5. **Wires:** Shall be Graphical elements used to form logical connections between microblocks and between logical I/O. Different wires types shall be used depending on whether the signal they conduct is analog or digital.
6. **Labels:** Labels shall be similar to wires in that they are used to form logical connections between two points. Labels shall form a connection by reference instead of a visual connection, i.e. two points labeled 'A' on a drawing are logically connected even though there is no wire between them.
7. **Parameter:** A parameter shall be a value that may be tied to the input of a microblock..
8. **Properties:** Dialog boxes shall appear after a microblock has been inserted which has editable parameters associated with it. Default parameter dialog boxes shall contain various editable and non-editable fields and shall contain 'push buttons' for the purpose of selecting default parameter settings.
9. **Icon:** An icon shall be graphic representation of a software program. Each graphic microblock has an icon associated with it that graphically describes it function.
10. **Menu-bar Icon:** Shall be an icon that is displayed on the menu bar on the GPL screen, which represents its associated graphic microblock.
11. **Live Graphical Programs:** The Graphic Programming software must support a 'live' mode, where all input/output data, calculated data, and setpoints shall be displayed in a 'live' real-time mode.

    For each piece of HVAC equipment, the entire graphic program shall be displayed through the Web Browser GUI. The operator must have the ability to scroll through the entire 'live' graphic program as necessary. Piecemeal graphic programs that only show one part of HVAC equipment program at any one time are NOT acceptable. For example, when viewing an AHU live graphic program, the operator shall see the entire AHU graphic program, not just the Heating Coil control.

PART 3 - PRODUCTS HARDWARE

3.1 BAS SERVER HARDWARE

A. Computer Configuration (Hardware Independent)

1. **Central Server.** The BAS Contractor shall provide a server configuration that includes the following components as a minimum:
2. 1 GHz, PIII or higher CPU (or non-Intel platform equivalent to this) – Dual Processor
3. 256Mb of RAM minimum, 512 MB RAM preferred.
4. 10 gigabyte hard disk, 1.44M 3 ½" floppy drive, SVGA Card with 1024 x 768, 24-bit True Color, Iomega 100MB Zip Drive or Back-up system of customer's choice, 24X CD Rom Drive, 17" SVGA Color Monitor, Keyboard and mouse, 56Kbps EIA-232C Modem with automatic answer/originate capability
5. Operating system for the computer operator workstation server shall be Microsoft Windows NT 4.0, 2000, XP or RedHat Linux 6.0 or Sun Solaris 7.0
6. Internet Explorer 6.0 or later
7. 10Base-T Ethernet Port
8. Printer capable of providing letter quality print (a color printer is preferred). Note: For reporting alarms, a printer capable of handling fanfold paper is desirable.

B. Standard Client

The thin-client Web Browser BAS GUI shall be Microsoft Internet Explorer (6.0 or later) running on Microsoft 98, 2000, NT, XP. No special software, (active-x components or fat java clients) shall be required to be installed on the PC's / PDA's used to access the BAS via a web browser. The following is the minimum suggested hardware requirements for a Windows/Intel client:

1. 500Mhz, PIII or higher CPU (or non-Intel platform equivalent to this)
2. 128Mb of RAM minimum
3. 6 gigabyte hard disk, 1.44M 3 ½" floppy drive, SVGA Card with 1024 x 768, 24-bit True Color, 24X CD Rom Drive, 17" SVGA Color Monitor
4. Operating system for the computer operator workstation server shall be Microsoft Windows 98, NT 4.0, 2000, or XP
5. Internet Explorer 5.5 or later
6. Connection to the Intranet/Internet

C. Web Appliances

The BAS thin client architecture shall take advantage of the browsers built into web appliances such as:

1. **Palm Pilot**
2. **Compaq iPaq**
3. **Web Tablets**

3.2 NETWORK ROUTERS & BRIDGES

The controller network shall use BACnet as its native communication protocol. Network bridges and routers must be of a modular design to ensure reliability and system performance.

A. BACnet Router

The central system shall use the building Local Area Network (LAN) for communication. The communication between the central server and the controllers shall be BACnet/IP. A router shall be provided, as required, to bridge BACnet/IP and the data link used between the controllers (BACnet over ARCNET or MS/TP). Proprietary protocols are NOT acceptable.

1. **BACnet BIBBS:** BACnet Routers must use BACnet as the native communication protocol and must, as a minimum, support the following BIBBS:

Data Sharing	Alarm Event	Schedule	Trend	Device Man.	Network Man.
DS-RP-A, B DS-RPM-B DS-WP-A, B DS-WPM-B DS-COVU-A, B	AE-N-B AE-ACK-B AE-ASUM-B	SCHED-B	T-VMT-B T-ATR-B	DM-DDB-A, B DM-DOB-B DM-DCC-B	NM-RC-A

2. **Firmware Updates.** The BACnet Router utilize FLASH memory to allow firmware updates to be performed remotely.

3.3 STANDALONE CONTROLLERS

A. General Purpose Multiple Application Controllers

1. **BACnet BIBBS:** General Purpose Multiple Application controllers must use BACnet as the native communication protocol between controllers and must, as a minimum, support the following BIBBS:

Data Sharing	Alarm Event	Schedule	Trend	Device Man.
DS-RP-A, B DS-RPM-B DS-WP-A, B DS-WPM-B DS-COVU-A, B	AE-N-B AE-ACK-B AE-ASUM-B	SCHED-B	T-VMT-B T-ATR-B	DM-DDB-A, B DM-DOB-B DM-DCC-B DM-TS-B DM-UTC-B DM-RD-B

2. **Communication Speed.** Controllers shall communicate at a minimum of 156 Kbps using ARCNET implemented over EIA-485 using a shielded twisted pair at the Data Link Layer.

3. **General Specification.** Each General Purpose Multiple Application Controller must be capable of standalone direct digital operation utilizing its own 32 bit processor, non-volatile flash memory, input/output, 12 bit A to D conversion, hardware clock/calendar and voltage transient and lightning protection devices. A separate co-processor shall be used for communications to the controller network. All non-volatile flash memory shall have a battery backup of at least five years. Firmware revisions to the module shall be made from the BAS server or remotely over the Intranet or Internet. Controllers that require component changes to implement firmware revisions are NOT acceptable.

4. **Point Expansion.** The General Purpose Multiple Application Controllers shall be expandable to the specified I/O point requirements. Each controller shall accommodate multiple I/O Expander Modules via a designated expansion I/O bus port. These expander modules shall expand the total point capacity of each controller up to 192 points where specified. The controller, in conjunction with the expansion modules, shall act as one standalone controller.

5. **Point Programming.** All point data, algorithms and application software within a controller shall be custom programmable from the operator workstation.

6. **Program Execution.** Each General Purpose Multiple Application Controller shall execute application programs, calculations, and commands via a 32-bit microcomputer resident in the controller. All operating parameters for application programs residing in each controller shall be stored in read/writ able nonvolatile flash memory within the controller and will be able to upload/download to/from the BAS Server.

7. **Self-Test Diagnostics.** Each controller shall include self-test diagnostics, enabling the controller to report malfunctions to the router and BAS Server.

8. **PID Loops.** Each General Purpose Multiple Application Controller shall contain both software and firmware to perform full DDC Proportional, Integral, Derivative (PID) control loops and programs.

9. **Input-Output Processing:**

   a. **Digital Outputs** shall be relays, 24 Volts AC or DC maximum, 3 amp maximum current. Each configured as normally open or normally closed using jumpers and provide dry contacts. Each output shall have a manual Hand-Off-Auto switch for local override and an LED to indicate the operating mode. Triac outputs are NOT acceptable.

   b. **Universal Inputs** shall be Thermistor (BAPI Curve II) 10K Ohm at 77°F (25°C), 0-5VDC, 10K Ohm maximum source impedance, 0-20mA - 24 VDC loop power, 250 Ohm input impedance, dry contact - 0.5mA maximum current.

   c. **Analog Output** shall be electronic, voltage mode 0-10VDC or current mode 4-20mA.

   d. **Analog Pneumatic Outputs** shall be 0-20psi. Each pneumatic output shall have a feedback transducer to be used in the system for any software programming needs. The feedback transducer shall measure the actual psi output value and not a calculated value. Each output shall have a manual override switch that will allow each output to be configured in one of three ways: open, closed, or automatic operation. An LED shall indicate the state of each output.

B. General Purpose Single Application Controllers

1. **BACnet BIBBS:** The General Purpose Single Application Controllers must use BACnet as the native communication protocol between controllers and must, as a minimum, support the following BIBBS:

Data Sharing	Alarm Event	Schedule	Trend	Device Man.
DS-RP-A, B	AE-N-B	SCHED-B	T-VMT-B	DM-DDB-A, B
DS-RPM-B	AE-ACK-B		T-ATR-B	DM-DOB-B
DS-WP-A, B	AE-ASUM-B			DM-DCC-B
DS-WPM-B				DM-TS-B
DS-COVU-A, B				DM-UTC-B
				DM-RD-B

2. **Communication Speed:** Controllers shall communicate at a minimum of 156 Kbps using ARCNET implemented over EIA-485 using an unshielded twisted pair at the Data Link Layer.

3. **General Specification:** General Purpose Single Application controllers must be capable of stand-alone DDC operation utilizing its own 32 bit processor, nonvolatile flash memory, input/output, 8 bit A to D conversion, hardware clock/calendar and voltage transient protection devices. A separate co-processor shall be used for communications to the controller network. All RAM memory shall have a battery backup of at least five years. Firmware revisions to the module shall be made from the BAS server, or remote locations over the Internet. Controllers that require component changes to implement Firmware revisions are NOT acceptable.

4. **Point Programming:** All point data, algorithms, and application software within the controllers shall be custom programmable from the Operator Workstation.

5. **Program Execution:** Each General Purpose Single Application Controller shall execute application programs, calculations, and commands via a 32-bit microcomputer resident in the controller. All operating parameters for the application program residing in each controller shall be stored in read/writ able nonvolatile flash memory within the controller and will be able to upload/download to/from the Operator Workstation.

6. **Self-Test Diagnostics:** Each controller shall include self-test diagnostics, enabling the controller to report malfunctions to the router and BAS Server input.

7. **PID Loops:** Each General Purpose Single Application Controller shall contain both software and firmware to perform full DDC PID control loops.

8. **Rooftop Mounting.** The General Purpose Single Application Controllers shall be capable of being mounted directly in or on rooftop AHU equipment.

9. **Operating Temperature.** The General Purpose Single Application Controllers shall be capable of proper operation in an ambient temperature environment of -20°F to +150°F (-28.9° to 65.6°C).

10. **Input-Output Processing:**

    a. **Digital Outputs** shall be relays, 24 Volts AC or DC maximum, 3 amp maximum current. Each output shall have a manual Hand-Off-Auto switch for local override and an LED to indicate the operating mode. Triac outputs are NOT acceptable.

    b. **Universal Inputs** shall be Thermistor (BAPI Curve II) 10K Ohm at 77°F (25°C), 0-5VDC - 10K Ohm maximum source impedance, 0-20mA - 24 VDC loop power, 250 Ohm input impedance, Dry Contact - 0.5mA maximum current.

    c. **Analog Electronic Outputs** shall be voltage mode 0-10VDC or current mode 4-20mA.

    d. **Enhanced Zone Sensor Input** shall provide one thermistor input, one local setpoint adjustment, one timed local override switch, and an occupancy LED indicator.

C. Unitary Controller Network

1. Unitary Controllers

a. **BACnet BIBBS:** The Unitary Controllers shall use BACnet as the native communications protocol between controllers on the unitary controller network and must, as a minimum support the following BIBBS:

Data Sharing	Device Man.
DS-RP-B	DM-RD-B
DS-WP-B	DM-PT-B

b. **Communication Speed.** The communication between unitary controllers shall be 38.4 Kbps minimum over EIA-485 using an MS/TP architecture.

c. **Sensor Support.** Each Unitary Controller shall be able to support various types of zone temperature sensors, such as; temperature sensor only, temperature sensor with built-in local override switch and temperature sensor with built-in setpoint adjustment switch.

d. **Airflow Transducer.** In order to provide reliable Pressure Independent VAV operation, Unitary Controllers for pressure independent VAV applications shall have a precision built-in Honeywell AWM series airflow transducer for accurate air flow measurement.

e. **Integral Actuator.** Each Unitary Controller for VAV applications shall have an integral direct coupled electronic actuator with the following features:

- The actuator shall provide on-off/floating point control with a minimum of 35 in-lb of torque.
- The assembly shall mount directly to the damper operating shaft with a universal V-Bolt clamp assembly.
- The actuator shall not require any limit switches, and shall be electronically protected against overload.
- The actuator shall automatically stop when reaching the damper or actuator end position.
- The gears shall be capable of being manually disengaged with a button on the assembly cover.
- A visual pointer for the position of the actuator.
- The assembly shall have an anti-rotational strap supplied with the assembly that will prevent lateral movement.
- 5-year warranty from the manufacturer.

f. **Visual Status.** Each Unitary Controller and Unitary Controller Interface shall have LED indication for visual status of communication, power, and all outputs.

g. **Standalone Algorithm.** In the event of a loss of communication, each Unitary Controller shall control from a standalone algorithm, which maintains the assigned space temperature until communication with the Unitary Control Router is restored.

h. **Input/Output Processing:**

- Digital outputs shall be relays, 24 Volts AC or DC maximum, having a 1 Amp maximum current. Each relay shall be configured as normally open or normally closed, and provide a dry contact. Triac outputs are NOT acceptable.
- Universal inputs shall be Thermistor Precon Type II, dry contacts or 0-5VDC with 0-10K Ohm input impedance.
- Enhanced Zone Sensor Input. The input shall provide one thermistor input, one local setpoint adjustment, one timed local override switch, and an occupancy LED indicator.
- Analog output electronic, voltage mode 0-10VDC

2. Unitary Controller Router

A router shall be provided to bridge between the unitary controller network and the main controller network, as required.

a. **BACnet BIBBS:** The Unitary Controllers Routers shall use BACnet as the native communications protocol between controllers on the unitary controller network and must, as a minimum support the following BIBBS:

Data Sharing	Alarm Event	Schedule	Trend	Device Man.
DS-RP-A, B	AE-N-B	SCHED-B	T-VMT-B	DM-DDB-A, B
DS-RPM-B	AE-ACK-B		T-ATR-B	DM-DOB-B
DS-WP-A, B	AE-ASUM-B			DM-DCC-B
DS-WPM-B				DM-TS-B
DS-COVU-A, B				DM-UTC-B
				DM-RD-B

3.4 LOCAL OPERATOR KEYPAD DISPLAY

A. Local Keypad Display (LOK)

1. **General Purpose Controller Plug-in.** Keypad and display shall be provided where indicated in the I/O summary. The LOK shall plug directly into any general purpose/multi application controller and enable maintenance personnel to access and modify specified building control parameters in any DDC control panel. The LOK shall be panel mounted [or wall mounted].

2. **Interface.** The LOK shall comprise a minimum of four function keys and employ a backlit display for easy reading in poor lighting conditions. Each function key shall act as a 'hot-key' to menus comprised of control parameters. The display shall utilize English language descriptors rather than cryptic code and a menu penetration technique to access data. Clearly marked 'up' and 'down' arrow keys shall be used to move between point descriptors listed in each menu. The LOK backlit display shall be 4 by 40 characters or 2 by 16 characters, as specified by location in the I/O Point Summary.

3. **Menu Language.** The English language menus in the LOK shall be constructed using industry standard HTML. Access to building control parameters shall be protected by password entry.

B. Local Control Panel Access:

Where shown on the drawings (or at each control panel location), the contractor shall provide an Ethernet drop which will allow the operator to have full use of the Web Browser GUI as specified in section 2.1 System Overview, E Thin Client – Web Browser Based. BAS Systems that require a laptop computer with central workstation software and database, in order to provide local access are NOT acceptable.

3.5 BUILDING SYSTEMS INTEGRATION

A. Protocol Translator Module

The BAS System shall establish a seamless interconnection with other building, electrical and/or mechanical subsystems as well as other manufacturers control systems using a Protocol Translator as specified below and related equipment sections of the specification. These systems shall be controlled, monitored and graphically programmed with the same Graphical Programming Language (GPL) used for all other control modules.

1. **System Information.** All system information specified in the I/O Point Summary and related documents shall be available to the BAS server.

2. **OEM Cooperation.** Full cooperation by the Original Equipment Manufacturer (OEM) in this open protocol effort shall be a requirement for bidding this project. OEM manufacturers shall bid BACnet. OEM manufacturers that utilize other protocols shall include the cost of a BTM in their bid. If the OEM manufacturer uses the LonWorks protocol, they shall certify their devices are LONMARK compliant and comply with the requirements of 2.1.C.2 of this specification.

3. **Necessary Equipment Included Price.** If the equipment manufacturer does not have this capability, they shall contact the authorized representative of the BAS for assistance and shall

include in their equipment price any necessary equipment obtained from the BAS manufacturer to comply with this section.

4. **PTM Specification:**

   a. The PTM shall be a microprocessor based communication device designed to provide seamless, two-way translation between two or more standard or non-standard protocols.

   b. The PTM shall be available for a variety of Data Link\Physical Layer configurations including PTP (point-to-point) via EIA-232, MS/TP via EIA-485, ARCNET and Ethernet.

   c. In addition to BACnet, the PTM shall also support other protocols including Modbus, J-Bus and other protocols as specified herein for electrical/mechanical subsystems.

   d. The PTM shall have at least three communication ports. One shall be for communication between native BACnet controllers residing on the controller network. The other two ports shall have the ability to be configured for different protocols.

   e. The PTM shall provide full custom programmability of the data flowing between the networks using the same graphical programming as specified herein. The system shall have the ability to create custom building control strategies using global data between networks.

3.6 FIELD HARDWARE/INSTRUMENTATION

A. Input Devices

1. **Type & Accuracy.** Temperature sensors shall be of the type and accuracy indicated for the application. Sensors shall have an accuracy rating within 1% of the intended use temperature range.

2. **Mixed Air Application.** Sensors used for mixed air applications shall be the averaging type and have an accuracy of +1°F (0.5°C).

3. **Outside Air Temperature Sensors.** Outside air temperature sensors accuracy shall be within +1°F (0.5°C) in the range of -52°F to 152°F (-46.6°C to 66.6°C).

4. **Room Temperature Sensors.** Room temperature sensors shall have an accuracy of +0.36°F (0.25°C) in the range of 32°F to 96°F (0°C to 35.5°C).

5. **Chilled Water and Condenser Water Sensors.** Chilled water and condenser water sensors shall have an accuracy of +0.25°F (0.15°C) in their range of application.

6. **Hot Water Temperature Sensors.** Hot water temperature sensors shall have an accuracy of +0.75°F (0.3°C) over the range of their application.

B. Pressure Instruments

1. Differential Pressure and Pressure Sensors
2. Pressure Switches
3. Flow Switches
4. Watt-hour Transducers
5. Voltage-to-Digital Alarm Relays
6. Humidity Sensors
7. Current Sensing Relays

C. Output Devices

1. Control Relays
2. Solid State Relays (SSR)
3. Electric Solenoid Operated Pneumatic (EP) Valves
4. Electric to Pneumatic (EP) Transducers

D. Valve and Damper Actuators

1. **Electronic Direct-Coupled.** Electronic direct-coupled actuation shall be provided.
2. **Actuator Mounting.** The actuator shall be direct-coupled over the shaft, enabling it to be mounted directly to the damper shaft. The fastening clamp assemble shall be of a 'V' bolt design with associated 'V' shaped toothed cradle attaching to the shaft for maximum strength and eliminating slippage. Spring return actuators shall have a 'V' clamp assembly of sufficient size to be directly mounted to an integral jackshaft of up to 1.05 inches when the damper is constructed in this manner. Single bolt or screw type fasteners are not acceptable
3. **Electronic Overload Sensing.** The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.
4. **Power Failure/Safety Applications.** For power failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable.
5. **Spring Return Actuators.** All spring return actuators shall be capable of both clockwise or counterclockwise spring return operation by simply changing the mounting orientation.
6. **Proportional Actuators.** Proportional actuators shall accept a 0 to 10VDC or 0 to 20mA control input and provide a 2 to 10VDC or 4 to 20mA operating range. An actuator capable of accepting a pulse width modulating control signal and providing full proportional operation of the damper is acceptable.
7. **24 Volts (AC/DC) actuators.** All 24VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 10VA for AC or more than 8 watts for DC applications. Actuators operating on 120VAC power shall not require more than 10VA. Actuators operating on 230VAC shall not require more than 11VA.
8. **Non-Spring Return Actuators.** All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb torque shall have a manual crank for this purpose.
9. **Modulating Actuators.** All modulating actuators shall have an external, built-in switch to allow reversing direction of rotation.
10. **Conduit Fitting & Pre-Wiring.** Actuators shall be provided with a conduit fitting and a minimum 3ft electrical cable, and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
11. **U.L. Listing.** Actuators shall be Underwriters Laboratories Standard 873 listed and Canadian Standards Association Class 4813 02 certified as meeting correct safety requirements and recognized industry standards.
12. **Warranty.** Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a 2-year manufacturer's warranty, starting from the date of installation. Manufacturer shall be ISO9001 certified.

PART 4 – DDC SOFTWARE

4.1 OVERVIEW

The system shall continuously perform Direct Digital Control (DDC) functions at the local control module in a stand-alone mode. Using Graphical Programming, the operator shall be able to design and modify control sequence of operation and all tuning parameters.

A. Minimum Function

Each control module shall perform the following functions:

1. Identify, time/date stamp and report BACnet events
2. Execute all application programs specified
3. Execute DDC algorithms
4. Trend and store data

B. Control Failure Mode

In the event of a control module failure, all points under its control shall be commanded to the failure mode as indicated on the I/O Summary Table. All DDC software shall reside in the respective control module.

1. **Orderly Shutdown**. Power failures shall cause the control module to go into an orderly shutdown with no loss of program memory.
2. **Automatic Restart.** Upon resumption of power, the control module shall automatically restart and print out the time and date of the power failure and restoration at the respective Workstation system.
3. **Automatic Restart.** The restart program shall automatically restart affected field equipment. The operator shall be able to define an automatic power up time delay for each piece of equipment under control.

PART 5 - APPLICATIONS SOFTWARE

5.1 GENERAL

All software application algorithms described below MUST reside at the local Multi-Application or Single-Application Controller level. Systems that rely on a workstation PC, server or router to perform these functions are NOT acceptable. The following applications software shall be provided for the purpose of optimizing energy consumption while maintaining occupant comfort:

A. Time of Day Scheduling (TOD)

The system shall be capable of the following scheduling features:

1. **Schedule by Type.** Scheduling by building, area, zone, groups of zones, individually controlled equipment and groups of individually controlled equipment. Each schedule shall provide beginning and ending dates and times (hours: minutes). A weekly repeating schedule, i.e. between 8:00 a.m. and 5:00 p.m., Monday through Friday shall constitute one schedule.
2. **Schedule in Advance.** Dated schedules shall be entered up to 9 (nine) years in advance.
3. **Self-Deleting.** Schedules shall be self-deleting when effective dates have passed.
4. **Leap Year.** Leap years shall be adjusted automatically without operator intervention.

B. Optimum Start/Stop (OSS)/Optimum Enable/Disable (OED)

This application provides software to start and stop equipment on a sliding schedule based on the individual zone temperature and the heating/cooling capacity in °F/hour of the equipment serving that zone. The heating/cooling capacity value shall be operator adjustable. Temperature compensated peak demand limiting shall remain in effect during morning start up to avoid setting a demand peak.

C. Source Temperature Optimization (STO)

The system shall automatically perform source optimization for all air handling units, chillers and boilers in response to the needs of other downstream pieces of equipment, by increasing or decreasing supply temperature setpoints, i.e. chilled water, discharge air, etc. using owner defined parameters. In addition to optimization, the STO capability shall also provide for starting and stopping primary mechanical equipment based on zone occupancy and/or zone load conditions.

1. **Setpoint Reset.** The STO program will allow setpoints for various equipment in the heating/cooling chain to be reset between an operator defined maximum and a minimum setpoint based on the actual requirements of the building zones. The actual setpoint shall be calculated based on the number of heating or cooling requests which are currently being received from the equipment or zones served. Once every update period, the STO program surveys the network to see if any piece of equipment requires any additional heating or cooling from its source. As an example, a VAV air handler is the source of cold air for a number of VAV boxes. Assume that the STO program for the air handler has the following parameters established for it by the owner:

Optimized setpoint description –

a. Initial setpoint is 60.00,
b. Max. setpoint is 65.00,
c. Min. setpoint is 55.00.
d. Every 2.0 mins, trim by 0.25 and respond by -0.50 but no more than 2.0.

Every two minutes, the STO program will total up all of the requests and calculate a new setpoint:

New setpoint = prev setpoint + 'trim by' + ('respond by' x no. of req.). Assuming four requests were received and the previous setpoint was 57.00 degrees, the new setpoint would be:

New setpoint = 57.00 + 0.25 + (-0.50 x 4) = 55.25 Deg F

If (the number of requests received) x (the 'respond by' value) > (the 'but no more than' value), use the 'but no more than' value inside the parenthesis in the above calculation.

D. Demand Limiting (DL) - Temperature Compensated

The DL application shall be programmable for a minimum of six separate time of day KW demand billing rate periods. The system shall be capable of measuring electrical usage from multiple meters serving one building and each piece of equipment being controlled on the LAN shall be programmable to respond to the peak demand information from its respective meter.

1. **Sliding Window.** The demand control function shall utilize a sliding window method with the operator being able to establish the kilowatt threshold for a minimum of three adjustable demand levels. The sliding window interval shall be operator selectable in increments of one minute, up to 60 minutes. Systems that incorporate rotating shed tables are NOT acceptable.
2. **Setpoints for Defined Demand Level.** The operator shall have the capability to set the individual equipment temperature setpoints for each operator defined demand level. Equipment shall not be shed if these reset setpoints are not satisfied; rather the setpoint shall be revised for the different established demand levels. The system shall have failed meter protection, such that when a KW pulse is not received from the utility within an operator adjustable time period, an alarm will be generated. The system software will automatically default to a predetermined fail-safe shed level.
3. **Information Archiving.** The system shall have the ability to archive demand and usage information for use at a later time. System shall permit the operator access to this information on a current day, month to date and a year to date basis.

E. Day/Night Setback (DNS)

The system shall allow the space temperature to drift down [up] within a preset [adjustable] unoccupied temperature range. The heating [cooling] shall be activated upon reaching either end of the DNS range and shall remain activated until the space temperature returns to the DNS range.

1. **Outside & Exhaust Air.** The system shall be capable of closing all outside air and exhaust air dampers during the unoccupied period, except for 100% outside air units.
2. **Unoccupied Space Temperature.** Unoccupied space temperature shall be monitored by the DDC temperature sensors located in the individual zones being controlled or within a representative room.
3. **Parameter Changes.** Operator shall be able to define, modify or delete the following parameters.
   a. DNS setpoint temperature(s)
   b. Temperature band for night heating operation
   c. Period when the DNS is to be activated

F. Timed Local Override (TLO)

The system shall have TLO input points that permit the occupants to request an override of equipment that has been scheduled OFF. The system shall turn the equipment ON upon receiving a request from the local input device. Local input devices shall be push button (momentary contact), wind-up timer, or ON/OFF switches as detailed in the I/O summary.

1. **Equipment On Time.** If a push button is used the system operator shall be able to define the duration of equipment ON time per input pulse and the total maximum ON time permitted. The input point will cancel override time already entered. If a wind-up timer is used the equipment will stay in override mode until the timer expires. Year to date, month-to-date and current day override history shall be maintained for each TLO input point. History data shall be accessible by the operator at any time and shall be capable of being automatically stored on hard disk and/or printed on a daily basis.

G. Space Temperature Control (STC)

There shall be two space temperature setpoints, one for cooling and one for heating, separated by a dead band. Only one of the two setpoints shall be operative at any time. The cooling setpoint is operative if the actual space temperature has more recently been equal to or greater than the cooling setpoint. The heating setpoint is operative if the actual space temperature has more recently been equal to or less than the heating setpoint. There are two modes of operation for the setpoints, one for the occupied mode (example: heating = 72°F or 22°C, cooling = 76°F or 24.4°C) and one for the unoccupied mode (example: heating = 55°F or 12.7°C, cooling = 90°F or 32°C).

1. **Schedule.** The occupied/unoccupied modes may be scheduled by time, date, or day of week.
2. **Color Code.** One of seven colors shall be generated to represent the comfort conditions in the space, and shall be displayed graphically at the operator station.
    a. If the actual space temperature is in the dead band between the heating setpoint and the cooling setpoint, the color displayed shall be green for the occupied mode, representing ideal comfort conditions. If in the unoccupied mode, the color displayed shall be gray representing 'after-hours' conditions.
    b. If the space temperature rises above the cooling setpoint, the color shall change to yellow. Upon further rise beyond the cooling setpoint plus an offset, the color shall change to orange. Upon further rise beyond the cooling setpoint plus the yellow band offset, plus the orange band offset, the color shall change to red indicating unacceptable high temperature conditions. At this point an alarm shall be generated to notify the operator.
    c. When space temperature falls below the heating setpoint, the color shall change to light blue. Upon further temperature decrease below the heating setpoint minus an offset, the color shall change to dark blue. Upon further space temperature decrease below the heating setpoint minus the light blue band offset minus the dark blue band offset the color shall change to red indicating unacceptable low temperature conditions. At this point an alarm shall be generated to notify the operator.
3. **Operator Definable.** All setpoints and offsets shall be operator definable. When in the occupied mode, start-up mode, or when heating or cooling during the night setback unoccupied mode, a request shall be sent over the network to other equipment in the HVAC chain, such as to an AHU fan that serves the space, to run for ventilation. The operator shall be able to disable this request function if desired.
4. **Additional Cooling.** When comfort conditions are warmer than ideal, indicated by the colors yellow, orange, and high temperature red, a request for additional cooling shall be sent over the network to other cooling equipment in the HVAC chain, such as a chiller. This information is to be used for optimization of equipment in the HVAC chain. The operator shall be able to disable this function if desired.

5. **Additional Heating.** When comfort conditions are cooler than ideal; indicated by the colors light blue, dark blue, and low temperature red; a request for additional heating shall be sent over the network to other heating equipment in the HVAC chain, such as a boiler. This information is to be used for optimization of equipment in the HVAC chain. The operator shall be able to disable this function if desired.
6. **Cooling/Heating Setpoints.** The cooling [and heating] setpoints may be increased [decreased] under demand control conditions to reduce the cooling (heating) load on the building during the demand control period. Up to three levels of demand control strategy shall be provided. The operator may predefine the amount of setpoint increase [decrease] for each of the three levels. Each space temperature sensor in the building may be programmed independently.
7. **Optimum Start.** An optimum start-up program transitions from the unoccupied setpoints to the occupied setpoints. The optimum start-up algorithm considers the rate of space temperature rise for heating and the rate of space temperature fall for cooling under nominal outside temperature conditions; it also considers the outside temperature; and the heat loss and gain coefficients of the space envelope (AI: Space Temperature).
8. **PID Loop.** A PID control loop, comparing the actual space temperature to its setpoint, shall modulate the dampers [and heating coil valve or heating stages in sequence] to achieve the setpoint target.

PART 6 - SEQUENCES OF OPERATION

<Insert desired control sequences of operation for the plant specified in the I/O Summary Schedule Addendum A, and all related contract documentation>

<Insert BACnet BIBBS interoperability requirements, see BACnet BIBBS specified for field controllers and routers in Addendum B>

PART 7 – OPEN SYSTEMS ARCHITECTURE